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On the use of Fiber Bragg Grating (FBG) technology to monitor volcano-hydrothermal systems (VHS): a case study from the Gunnuhver geothermal area, Iceland

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Most volcanoes on Earth are associated with hydrothermal systems. These so-called volcano-hydrothermal systems (VHS) typically develop between the magma chamber and the Earth's surface, where cooler surface water or groundwater percolates through permeable rocks and mixes with hot magmatic fluids from the deeper magma chamber (Heap et al., 2015). VHS hold great potential as a source of geothermal energy, but they also play an important role in the mechanism of phreatic and hydrothermal eruptions. Therefore, a thorough understanding of the dynamic behavior of these systems is paramount. Processes within the VHS, however, such as (hydrothermal) fluid circulation, phase changes, magmatic-hydrothermal interactions or pore-pressure changes, induce several geophysical and hydrothermal signals. These include, among others: seismic signals (e.g. tremor, Long Period (LP) events), stress and strain variations, variable ground resistivity, temperature changes and ground deformation (e.g. Currenti & Napoli, 2017; Caudron et al., 2023). This multitude of signals complicates our understanding of the internal dynamics of the VHS, and the detection of pre-eruptive signals. Hence, to gain better insight into the complex inner workings and nature of VHS, a multi-disciplinary investigation approach and efficient monitoring techniques are required. Traditional methods to study VHS include geodetic, geochemical and geophysical methods (Calò et al., 2021). Recent efforts, however, also consider alternative techniques to characterize these systems (Vanhooren et al., 2023).

In this study, a VHS (the Gunnuhver geothermal area on the Reykjanes Peninsula, Iceland) was monitored for the first time using fiber optic sensing technology. Fiber Bragg Grating (FBG)-based fiber optic sensors, cascaded along a telecom-grade optical fiber, were installed in the ground to continuously monitor strain and temperature variations in the geothermal field at a sampling frequency of 0.5 Hz and a spatial resolution of 5 m. An FBG is a periodic variation in the refractive index of the core of an optical fiber. Upon exposure to light from a broadband source, it only reflects light of a specific wavelength—the so-called Bragg wavelength—and transmits all other wavelengths. When the FBG is subjected to axial strain or temperature variations, it causes a shift in the reflected Bragg wavelength. This allows the FBG to act as a local and precise strain- and/or temperature sensor (Werneck et al., 2013).

The aim of this work is to analyze the strain- and temperature data provided by the FBG sensors, collected over approximately five months (from 17 September 2022 to 28 February 2023). This analysis will help to evaluate the potential of FBG sensors for VHS monitoring and could provide valuable insights into the activity of the VHS.

Overall, both the temperature- and strain datasets exhibit similar periodic behaviors, although certain periodicities are less pronounced in the strain data. This indicates a close relationship between temperature and strain, possibly suggesting that a significant part of the observed strain is due to thermal effects rather than pure mechanical deformation. Generally, a daily periodicity is most prominent. Occasionally, other periodicities (2–3 days; 4–5 days) dominate the signal, and sometimes small fluctuations are superimposed on the daily periodicity. We suggest that these cycles are driven by external factors (e.g. day-night alteration, weather conditions), dynamic processes inherent to the VHS (e.g. altered fluid flow, pore pressure changes), or a combination of both.

Although the temperature data are clearly influenced by external factors, they also reflect the overall soil temperature distribution in the area (Fig. 1, top). Several distinct temperature zones can be distinguished, providing an insight into the most active zones of the VHS and reflecting its heterogeneous nature. Zones with higher temperatures are composed of hydrothermally altered clays that lack vegetation, and these areas exhibit a greater number of hydrothermal surface features. On the other hand, zones with lower temperatures are characterized by vegetated soils, and they display fewer hydrothermal surface features. In addition, the temperature sensors also reveal several 'hot spots'—local areas where the temperature is significantly higher than in the immediate vicinity. These may be due to the presence of local fumaroles or rising steam.

Furthermore, the data reveal some interesting features. These include gradual increases in strain signal amplitude (so-called "thickenings"), and sudden changes (increases or drops) in strain- or temperature signals (so-called "jumps") (Fig. 1, bottom). We wrote a code in Python to automatically detect these events within the dataset. The output of this code shows

that some thickening events are detected simultaneously by several different strain sensors. Further analysis of the duration and frequency content of these thickenings suggests that they may represent hydrothermal- or volcanic tremor. The nature of the jumps is more ambiguous and needs further investigation.

In conclusion, this preliminary assessment suggests that FBG sensors could provide valuable information on VHS, at a high spatial resolution. The combined influence of external and internal factors on the strain- and temperature signals, as well as the complex interplay between strain and temperature itself, complicates the interpretation of the observed signals and periodicities. Further research and comparison with traditional techniques would be required to assess the full potential of FBG-based VHS monitoring.

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Temp (°C)	median	min	max
5_1	7.570705	-6.5765214	20.358492
5_2	10.2273194	-1.4095196	18.5839566
5_3	9.6914682	-0.6142334	18.674523
5_4	10.1641116	1.047094	17.4631974
5_5	12.9971418	2.0291734	20.9462302
5_6	9.7669402	0.1159582	17.1254602
5_7	11.1801534	3.2886124	17.3414988
5_8	138.093869	15.6735676	154.592048
5_9	12.7259143	5.2414504	19.3858466
5_10	10.7905292	1.6820022	17.7339532
5_11	10.8546804	2.1904948	18.8075424
5_12	10.1749607	1.17917	18.82075
5_13	13.410351	6.5405122	21.3009486
5_14	15.8905496	5.462206	23.4075608
6_1	13.8947869	1.1867172	23.6585052
6_2	16.028286	5.8244716	23.4754856
6_3	14.834885	2.6395532	23.4254854
6_4	24.3764326	10.8669446	39.4925308
	median	min	max
6_5	23.099069	20.2094348	29.839662
6_6	43.5345281	32.1566524	55.3576886
6_7	165.025108	127.750431	183.386503
6_8	31.3283472	24.4085082	41.952918
6_9	39.8151736	34.6859078	48.8953986
6_10	22.0103854	19.4981112	25.33021
6_11	15.1386598	9.683921	23.858506
6_12	19.5103754	13.7518618	21.9471776
6_13	50.132196	45.0765154	57.4076968
6_14	38.712339	15.9688518	47.8982248
7_1	137.763679	58.882231	200.167702
7_2	24.0688842	4.9405058	47.1623728
7_3	22.9651062	6.1820202	34.6010018
7_4	19.7839614	1.69804	33.4443934
8_1	32.108539	13.4395964	72.8851172
8_2	46.4265208	32.6358996	97.2672902
8_3	36.4783678	19.636791	48.0397348

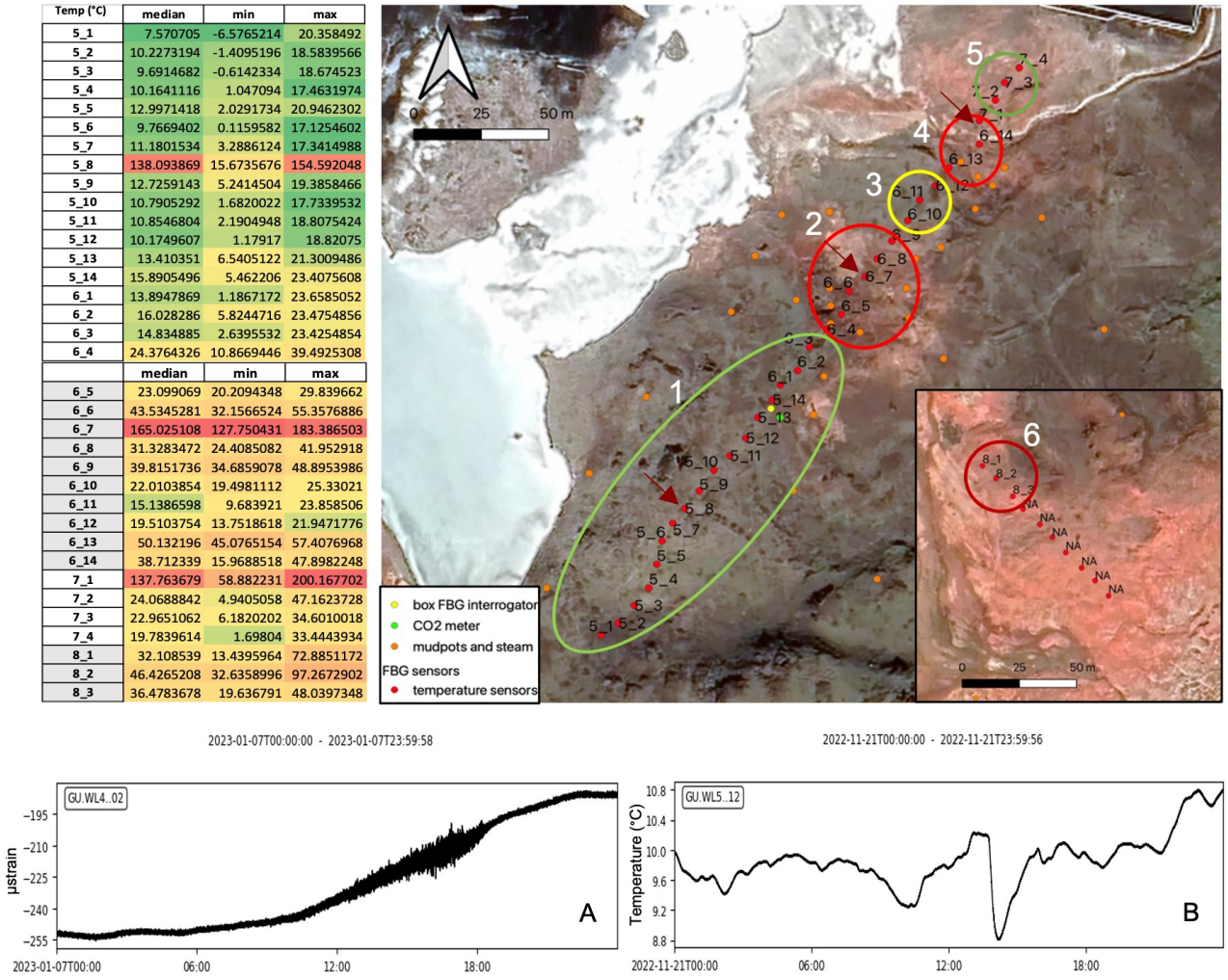

Figure 1. Top: Soil temperature distribution map. Six different temperature zones (ellipses) were identified in the field. Red arrows indicate sensors with anomalously high temperature readings. Table shows median, minimum and maximum temperature values recorded by the temperature sensors throughout the study period (in °C). Temperatures are color-coded: green = lowest temperature, red = highest temperature. Bottom: A) Thickening in strain signal; B) Jump in temperature signal.

Zoning in pyroxenes from Fogo, Cape Verde: Insight into the plumbing system

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In this study, bulk-rock geochemical data were obtained for 17 samples from lava flows from the 1769 and 1951 eruptions of Fogo (Cape Verde), using X-ray fluorescence. All samples from both eruptions are classified as tephrites/basanites. Optical and Scanning Electron Microscopy (SEM) was used for qualitative description of the textures and zoning patterns in the clinopyroxenes of the 17 lava samples and of 6 clinopyroxene megacrysts. Electron Probe Microanalysis (EPMA) was used to obtain quantitative compositional data for selected clinopyroxene phenocrysts.

Clinopyroxene crystals in all samples show complex zoning patterns, often combining patchy, concentric and sector zoning. Most crystals have hourglass sector-zoned rims, characterised by an enrichment of Si – Mg and depletion of Al – Ti in the {-1 1 1} hourglass sector relative to the {1 0 0}, {1 1 0} and {0 1 0} prism sectors. This type of sector zoning is formed at near-equilibrium conditions during low degrees of undercooling (Ubide et al., 2019). In some clinopyroxene crystals, Ca and Na also partition into sectors, signalling the transition to disequilibrium conditions and thus higher degrees of undercooling.

The clinopyroxene crystals display several disequilibrium textures, including resorbed clinopyroxene cores with both more primitive (dark cores) and significantly more evolved compositions (green cores), suggesting that magma mixing between several small reservoirs occurred.

Based on our observations and available data from literature we propose the following model for magma plumbing before the 1769 and 1951 eruptions: melts are originally stored at depths of 24–30 km in the upper mantle and interact with several small reservoirs as they rise to shallower levels. Melts from different eruptions interact with different small melt pockets, as is illustrated by the absence of the more evolved green core pyroxenes in the tephrites/basanites of the 1769 eruption. The magma then stalls at depths of 17–22 km, where the sector-zoned rims of the clinopyroxenes are formed at dominantly near-equilibrium conditions and low degrees of undercooling. For a very limited time during the eruptions, melts stagnate in the crust at depths of 9–13 km, as indicated by the re-equilibration of fluid inclusions. There is no petrological evidence for long-lived magma storage in the crust beneath Fogo.

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Quaternary sediments of the southern North Sea – Core analyses in aid of paleo-reconstructions: A case study of the Brown Bank, The Netherlands

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The Brown Bank (BB), a sand ridge located midway between the Dutch and British coastlines of the southern North Sea, is a site of interest thanks to the recovery of archeological and paleontological material, including tools, human remains, etc., of Mesolithic age (10–7.5 ka BP) (Peeters & Amkreutz, 2020; Missiaen et al., 2021). They were found ex situ by e.g. dredging a large area, which emphasizes the need to advance paleo-landscape research to pinpoint areas of archeological potential where these artifacts could be retrieved in situ (Missiaen et al., 2021).

This master thesis research combines ultra-high-resolution parametric echosounder sub-bottom profiler (PES) and core data obtained during several surveys (2018–2022). Core data include lithological descriptions, multi-sensor core logging (MSCL) data (density and magnetic susceptibility), micropaleontological analyses of pollen, ostracods, foraminifers and diatoms, as well as optically stimulated luminescence (OSL) and radiocarbon dates. Interpretation of this dataset yields four acoustic units (AU), which represent eleven lithological units (LU). Paleoenvironmental analysis of the fossil content and correlation between cores further aid in determining the environmental evolution of the BB area.

During past glacial periods (e.g. the last glacial MIS5e-2), sea levels were globally more than 100 m lower than today, with the southern North Sea subaerially exposed and consisting of a low-lying area in which large rivers coalesced and drained the European continent. Around 11–9.5 ka, based on ^{14}C-dates, rising groundwater levels, caused by rising sea level, led to freshwater peat development in vegetated slow-flowing and stagnant water bodies, along with deposition of organic-rich sands (Fig. 2). Previously analyzed pollen data indicate pine trees prevailing in a marsh environment, with increasing amounts of deciduous trees. Around c. 9.5 ka, two small sandy, dominantly freshwater deposits with a small brackish signal in the diatom composition, hint to a first phase of tidal influence in these rivers. Shortly after, fine laminae of clay and fine sand and brackish microfossils indicate widespread estuarine tidal flats, creeks and shallow rivers until c. 8.5 ka. The approaching coastline is marked by an increase in salinity and depositional energy. For this period, the pollen data indicate the presence of marsh conditions at the edge of a pine, elm, oak and hazel forest. After a period of erosion, from c. 8 ka onwards, shelly sands indicate high-energy marine conditions.

Some important conclusions and hypotheses result from this reconstruction. (1) The presence of dominantly freshwater deposits above the peat layer has hitherto not been described in the literature. Their origin requires more research. A possible explanation is an estuarine system comparable to that of the river Scheldt (Belgium) today, where the tidal influence reaches far inland, but with predominantly fresh environmental conditions. (2) The freshwater peat can be used as a limiting point for sea-level reconstructions. (3) Preliminary mapping of the tidal sediments suggests a complex channel network. Its orientation allows to hypothesize that the first marine influence entered the area from estuaries north of the BB area. (4) From our acoustic data, there appears to be no indication that the BB

was already a topographic upstanding feature during the Mesolithic, as suggested by Missiaen et al. (2021).

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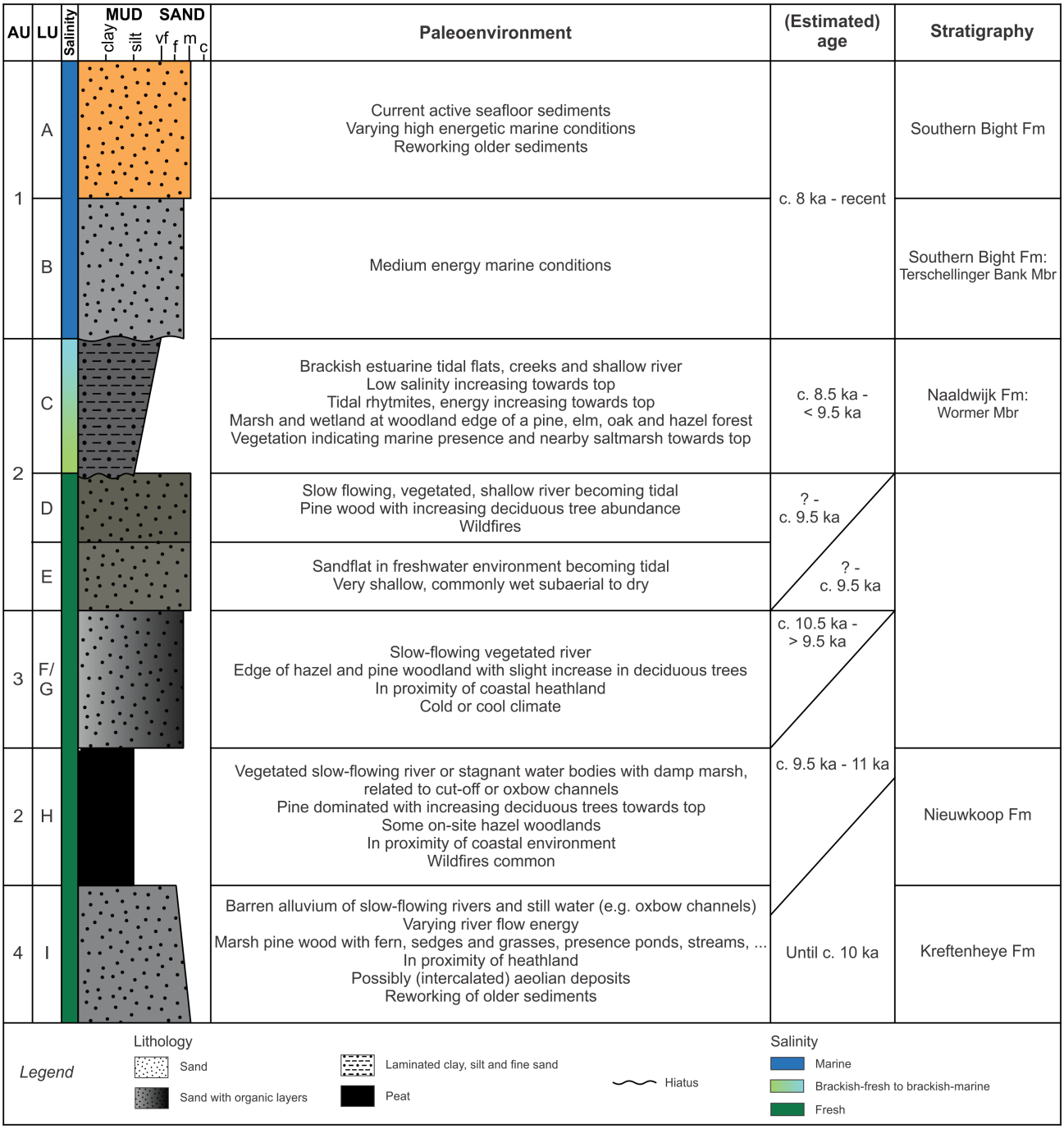

Figure 2. Conceptual model of the paleoenvironmental evolution of the Brown Bank area based on a composite log of all encountered lithological units (LU) and their corresponding acoustic units (AU). Fm = Formation; Mbr = Member.

Mineralogical and geochemical study of the supergene alteration associated with the Cu-Co mineralisation in the Tenke-Fungurume district (Katanga, DRC)

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The sediment-hosted Tenke-Fungurume (TFM) area is located in the northern margin of the world-class Central African Copperbelt and is one of the highest Cu-Co grade districts in the world (Schuh et al., 2012). The multiphase stratiform and epigenetic sulphide mineralisation is hosted in the Neoproterozoic carbonate and siliciclastic rocks. Superimposed upon primary mineralization, a Late Miocene supergene alteration event led to the remobilization and reprecipitation of Cu-Co mineralization (Decrée et al., 2010). The studied Kwatebala and Katuto deposits are hosted in the Mines Subgroup, while the Kyaundji prospect is hosted in the Lusele Formation of the Gombela Subgroup. The studied samples originate from different boreholes crossing the oxidised, mixed and hypogene zone of the Kwatebala deposit, the deep oxidized zone at Katuto and the shallow oxidized zone at Kyaundji.

This study aims to mineralogically and geochemically characterise the ore mineralisation and host rock alteration products to propose a synthetic metallogenic model of the supergene enrichment at the scale of the district. Microscopical investigation by optical microscopy of thin sections and polished sections coupled with mineralogical analysis (quantitative XRD Rietveld refinement on bulk rock and complemented by the <2 µm clay fraction investigation) as well as geochemical analyses on major and minor elements by Inductively coupled plasma – optical emission spectrometry (ICP-OES) both on host rock and ore mineralisation were carried out.

The sulphide mineralisation in the Tenke-Fungurume district is composed of chalcopyrite, bornite, carrollite, chalcocite, digenite and covellite while the non-sulphide supergene mineralisation consists of malachite, azurite, heterogenite, pseudomalachite, heterogenite, spherocobaltite and tenorite. Alteration is characterised by intense dissolution of the dolomitic host rock and precipitation of hematite, goethite as well as supergene dolomite and barite. After separation using the standardized Jackson's treatment and Na-saturation, XRD analysis shows that the clay fraction consists of smectite and kaolinite. These minerals are interpreted to originate from the hydrolysis of chlorite and feldspar. The geochemical analysis preceded by acid digestion of the sample powder reveals an increasing Co, Ni, Ba and V concentration with alteration in Katuto, along with a Cu depletion with regard to the proto-ore at Kwatebala. In contrast, no significant depletion or enrichment characterises the altered and fresh rock at Kyaundji.

These investigations allow the determination of distinctive alteration zones: the Kwatebala deposit is characterised by an upper-leached cap overlying a "green cementation zone" (100 to 145 m) that contains the bulk of the malachite and Fe-oxyhydroxides, with a strong lithological control on the alteration. This zone is directly underlain by the hypogene zone (proto-ore, 2.70 wt% Cu and 0.08 wt% Co) containing unaltered sulphides. The Katuto deposit is characterised by an alteration which develops at a depth of 400 to 620 m with a strong lithological and structural control on the distribution of the Co-Cu oxide alteration products. This alteration zone is associated with an increase in the Co grade (5.25 wt%) and a decrease in the Cu grade with regard to the proto-ore and is interpreted to be the result of the decoupling of the mobility of copper and cobalt in the oxidized zone. Finally, the alteration in the brecciated rocks at Kyaundji (0 to 8 m) is strongly structural controlled and shows a substantial in situ neutralisation of the alteration fluid due to the presence of a carbonate-rich environment, accountable for the precipitation of azurite and the highest Cu grade (11.02 wt%). In addition, a Co content of 0.07 wt% in altered rocks at Kyaundji is interpreted to be related to the superficial situation of the prospect and was attributed to a Co-rich cap. This comprehensive study enhances our understanding of the Tenke-Fungurume district's geological complexities, providing valuable insights into the metallogenic processes governing supergene enrichment.

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Geophysical and geomorphological analysis of rock avalanches in the Bernese Alps (Oeschinensee, Kandersteg and Elsigsee)

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This thesis focuses on the study of the Oeschinensee and Kandersteg rock avalanches and Elsigsee Valley located in the Bernese Alps (Switzerland), using the passive geophysical method HVSR (Horizontal to Vertical Spectral Ratio). The Elsigsee Valley was subjected to a geomorphological study through spatial analysis. The study of satellite images, in conjunction with geological maps and field analyses, have provided a more detailed characterization of the terrain in this valley.

The HVSR method applied to the natural dam of Oeschinensee has allowed for the identification of interfaces between the different deposits constituting it (which were previously modelled by ETH Zurich) and their respective thickness. The alluvial and avalanche deposits located in the Kandersteg Valley have also been examined, with their estimated thickness aligning with values obtained from prior drillings.

Given the Elsigsee Valley's lack of comprehensive geological examination, a detailed geomorphological analysis is presented here to explain the chaotic aspect of the deposits comprising the northern part of the valley. Spatial analysis and its geomorphological interpretations have unveiled a potential connection between the chaotic aspect of the in situ deposits and their source: a potential rock avalanche. This contradicts the data from the Swiss Geological Atlas, which attributes a glacial origin to these deposits. The conducted HVSR study could have aided in confirming or refuting either hypothesis.

However, the outcomes of this study have proven disappointing and have not provided clarity regarding the origin of these deposits. An investigation into wave polarization was

conducted across the data, but no preferential polarization direction was indicated within the studied area. Lastly, the quality of HVSR data interpretations made here was constrained by the absence of local S-wave velocity values, which are essential for a more nuanced interpretation of the frequencies obtained during the HVSR studies. This final aspect presents an opportunity for future supplementary research.

Geoelectrical surveys to reveal the dynamics of volcanic hydrothermal systems

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Volcanic hydrothermal systems (VHS) are three-phase reservoirs located between magma intrusions and the Earth's surface, and can be found in most volcanoes on Earth. The dynamical processes occurring within a VHS are still poorly understood. By characterizing these processes, their implications on geothermal systems, geohazards and phreatic or hydrothermal eruptions can also be identified in more detail. Variations in temperature, liquid saturation, and hydrothermal alteration are examples of dynamic processes occurring in the shallow part (<150 m) of a VHS that can affect the electrical properties of the subsurface. The geoelectrical methods, electrical resistivity tomography (ERT) and self-potential (SP), are sensitive to these variations and can reveal changes occurring through time because of for example water and gas flow, and temperature changes at the surface induced by volcanic activity. While using these methods to characterize volcanic environments is common practice (e.g. Grobbe & Barde-Cabusson, 2019), they have not been widely investigated to monitor VHS at a daily resolution until now.

High-resolution spatial imaging of the electrical properties of the subsurface can be obtained using ERT. The electrical resistivity characterizes how easily an electrical current can flow through a medium in the subsurface and is sensitive to various parameters including porosity, saturation, electrical conductivity of the pore fluid (influenced by salinity and temperature), presence of clay (surface conductivity) and (semi-)conductive minerals. Complementary information can be obtained using SP, because this method is influenced by oxido-reduction, fluid flow and diffusion/conduction processes (Grobbe & Barde-Cabusson, 2019).

The Gunnuhver hydrothermal system located in the Reykjanes geothermal area in the southwest of Iceland was investigated in this work, which is part of the research project ERupT. ERT and SP surveys were carried out in September 2022 to help characterize the study area. Since then, daily ERT measurements have been acquired. Besides the characterization of the study area, investigations of advanced inversion techniques for (time-lapse) ERT were explored. Absolute ERT inversions with and without a reference model, and time-lapse ERT inversions (difference and time-constrained inversions) combined with different types of error models were carried out.

Inversions with a reference model resulted in the most realistic ERT results for characterization. Based on these ERT results combined with the SP results, areas with a varying degree of hydrothermal alteration could be identified. Basaltic rocks with the lowest degree of hydrothermal alteration, characterized as resistive with stable SP signal, represent the largest part of the study area. Three active zones with a high degree of hydrothermal alteration, with low resistivity and large SP anomalies, could be distinguished. Below these zones of alteration, a very low resistive layer is observed on the ERT results representing saline groundwater.

The difference inversion technique (Kemna et al., 2002) resulted in the most realistic time-lapse ERT results. Abrupt daily variations between October 2022 and February 2023 are observed in the ERT inversion results of the study area probably linked to variations in liquid saturation and temperature in the identified active areas, and in a lesser degree mineral precipitation. Ongoing research focuses on revealing the dynamic behaviour of the volcanic hydrothermal system of Gunnuhver by comparing ERT results with direct observations. Changes in measured resistance are observed and possibly linked to pre-eruptive signals and deep earthquakes.

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Exploring ice-water-rock interactions underneath the Vatnajökull ice sheet (Iceland) with seismic noise

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A solid comprehension of the fundamental interactions at the glacier's base is essential for effectively managing the entirety of glacier dynamics. Despite the crucial significance of basal interactions, only limited continuous data is currently accessible for glaciers and ice sheets. This data scarcity primarily results from the challenging accessibility of the subglacial environment. While some techniques exist for interface analysis, these methods are often spatially restricted or provide only instantaneous snapshots in time. Utilizing cutting-edge seismology methods appear to offer a non-intrusive solution for providing continuous spatial observations (Labedz et al., 2022). Throughout the following work, we will investigate this approach and try to characterize the interactions occurring at the glacier base, particularly focusing on subglacial hydrology using passive seismology.

To characterize these interactions, we utilized data collected in May and June 2022 from the Sidujökull glacier, as well as the Skafta and Grimsvötn cauldrons. Geophones of the SmartSolo© IGU-16HR 3C 5Hz type were deployed on the ice for this purpose. All these locations are situated on Iceland's Vatnajökull glacier. Additionally, a broadband seismometer

(BB) was installed near one of the geophones on Grimsvötn's ice shelf. Furthermore, the permanent seismic network of Iceland (Icelandic Meteorological Office, 1992) was employed to assess seismic velocity variations spanning the years 2018 to 2022. These seismic data underwent analysis using three primary methods. Firstly, we employed the Glacial Hydraulic Tremor (GHT) approach, developed by Gimbert et al. (2016), based on a numerical model. This technique involves examining the relationship between the Power Spectral Density (PSD) of seismic noise within discrete frequency bands and water discharge. Its purpose is to characterize the state of subglacial channels. The second method used is Horizontal-to-Vertical Spectral Ratio (HVSR or H/V). This technique is used to determine the fundamental resonance frequency (f_0) of sites as a function of ice thickness. Given the extended duration of deployment, we conducted continuous analysis of both f_0 and H/V amplitude. And finally, we determined the seismic velocity changes that occurred beneath the Vatnajökull.

During the deployment of the nodes on the Sidujökull glacier, water discharge recorded two large increases. One of these increases was successfully recorded by all the nodes installed on the glacier. However, the relationships between the upper and lower parts of Sidujökull are different. The interpretation of the results suggests that the upper part of the glacier is governed by an increase in subglacial channels diameter due to water friction, as mentioned in the literature. Meanwhile, the results from the lower part suggest that the drainage system had switched from a distributed geometry to a pre-existing channelized configuration. However, the theory proposed by Gimbert et al. (2016) is still not validated, so the interpretation must be taken with caution. Continuous H/V results derived from the geophones installed on Sidujökull and on the Grimsvötn showed respectively variations in H/V amplitude and f_0. However, we were not able to determine the f_0 in the analyzed frequency band for the nodes installed on Skafta cauldrons. The changes in H/V amplitude were attributed to changes in wind velocity, which create noise in the sensor's vertical component, whereas the observed f_0 variations could be due to water intrusion in the Grimsvötn ice shelf basal crevasses. Another hypothesis for these variations is that the seismic noise source had become more distant. However, the f_0 variations are corroborated by the long-period displacement of the BB installed on the ice shelf. With the BB, we also observed oscillations with a frequency of 0.2 Hz, similar to those observed by Fichtner et al. (2022). Annual seismic velocity changes were observed in a range of ± 0.2% in the frequency domain of 0.1–1.5 Hz. Based on the Rayleigh sensitivity kernel, these variations were localized at the base of the ice sheet. The seismic velocity decrease occurred nearly at the same time as the snow melting period. Consequently, these variations were attributed to changes in medium water content (e.g. Luo et al., 2023; Mordret et al., 2016; Zhan, 2019).

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The **Geologica Belgica Master Day** is an annual event organised by the scientific association *Geologica Belgica Luxemburga Scientia & Professionis* to give recently graduated students in Geosciences the opportunity to present their Master thesis research in a competitive inter-university context. The 2023 edition of the Master Day took place on 13 October at the University of Mons.

The eight graduates who presented the results of their Master thesis during the Master Day organized this year in University of Mons. They came from UGent, KULeuven, ULiège and ULB.

The award winner of the Master Day, Hanne De Lathauwer, receiving her diploma from the president of *Geologica Belgica Luxemburga Scientia & Professionis*.